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Submarine Signal Co., CM-410
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HISTORY OF THE INTERIM GUIDANCE RADAR
SUBMARINE SIGNAL CO.

By
Henry J. Riblet
Submarine Signal Co.
Boston, Mass.

[redacted]

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A B S T R A C T

The thinking which led to the present dual pulse guidance system is reviewed.

Signed _____

Approved _____
Project Engineer

Approved _____
Asst. Chief Engineer

HISTORY OF SUBMARINE SIGNAL COMPANY

I.G.R.

The problem of guiding a beam riding missile involves the separate functions of tracking the target and guiding the missile. The principal phases of each are listed below:

Tracking

1. Acquisition
2. Tracking
3. Continuous Look Through

Guidance

1. Launching
2. Mid-Course Guidance
3. Homing

Early in 1946, the Submarine Signal Company was asked to investigate the problem of designing a ground guidance radar which would provide for the above functions in a single antenna structure, insofar as possible. In view of the complicated nature of any reasonable syste it was soon decided to proceed without any consideration of the "continuous-look-through" feature. The question of the homing phase, although not of immediate concern to Submarine Signal, must, however, certainly be provided for if a passive system is to be employed.

At present, Submarine Signal is constructing a rapid sequential, mechanically lobed, tracking and guidance system in which the spacing between pulses from separate magnetrons on different frequencies conveys to the missile the basic sense information. ~~It is~~ the object of this memorandum to explain just

why a double pulse system is being employed when a single pulse arrangement is capable, in the present system, of doing the job.

Of course, the present plans evolved from a number of conferences between Mr. E. Sanders at JHU/APL and Submarine Signal engineers. Early thinking was fundamental and long range in scope. Peak power as great as 1 mega-watt, at x-band, and a 16' antenna were seriously discussed. At all times a system capable of the ultimate in performance was the goal. Electronic switches, which would operate at both high and low power and at sufficiently high speeds so that all of the guidance information required could be delivered to the missile in a few microseconds, were freely postulated. The approach of delivery dates has forced a retreat from many of the objectives but in all cases the retreat has been made with an eventual recovery in mind.

For convenience, the ultimate goals together with the present compromises are listed below:

	Goal	Present System
1.	1 mega watt	50 K. W.
2.	15' antenna	7' antenna
3.	Monopulse or fast lobing	1/125 sec tracking interval
4.	Guidance within a few μ.s.	1/125 sec guidance interval
5.	Guidance with one lobe & one pulse	Guidance with one lobe and one pulse
6.	Non lobed transmitting beam for passive homing	Lobed transmitted beam
7.	Identical tracking and guidance paths	Identical tracking and guidance paths
8.	50% Crossover for tracking and guidance (N.B.)	50% Crossover for tracking(round trip) 70% Crossover for guidance

It should be observed that the goals appeared to be reasonable objectives a year ago but that they will certainly require revision in view of present information. For example, complete guidance information within a few microseconds appears to be entirely unnecessary in view of the 1/2 sec or so aerodynamic response time of the missiles and the fact that flame attenuation does not appear to be the hazard once anticipated.

Items 1, 3, 4, 6, and 8 are closely associated with a system in which the transmitted power is not lobed. The mechanical switch capable of handling power at the megawatt level is going to be an extremely difficult component to develop. Neither of the two systems, now operating, which give the greatest promise of smoother tracking than is now obtainable with conically scanning antennas, switch high power. The advantages of not lobing the transmitted beam are obvious when passive homing is employed. The relationship of 8 to the various types of systems is not simple but it is certainly true that the system being built at present cannot meet this requirement.

On the basis of these considerations, it was decided that, in an ultimate system, the transmitted pulse, used for tracking, should not be lobed. Since it appears convenient to lobe the guidance pulses, the suggestion of a double pulse guidance system appears to be a reasonable one from the long term point of view.

It should be pointed out that with present components all of the requirements of the ideal system could now be met except for items 1 and 4.

In spite of the attractive long term possibilities of a double pulse guidance system in which the transmitted tracking

power is not lobed and the fact that the basic techniques necessary to accomplish this result are on hand, the Submarine Signal Company is constructing a system in which the tracking pulses are lobed. This is being done because it is felt that the present system, as seen from the bird, is, for test purposes, essentially indistinguishable from the ultimate system; and, since it is a simpler system, it should make it possible for us to concentrate on the features of our system peculiar to the bumblebee project while the difficulties in the monopulse and fast lobing systems, still in the research stages, are resolved.

It is our hope that, when the present work is completed and the guidance system is thoroughly shaken down, we shall be able to incorporate in it the latest automatic tracking system. It is with this in mind that Submarine Signal Company has been active in soliciting and completing subcontracts from N.R.L. relating to the development of wave guide components for their monopulse system, and attempting, wherever possible, to so design the present system that different r.f. gadgetry and circuitry can be tried out later with a minimum of expense in time and money.

N.B. These are in the neighborhood of the optimum crossovers from the point of view of maximum error signal to error noise ratio on the assumption that all the noise under consideration is varied by the a.v.c. in the same manner as the r.f. signal. However, for guidance purposes some other criterion may be more important since the r.f. signal to receiver noise ratio may be so large that the error noise is negligible. For example, acquisition problems may indicate a much lower crossover for the guidance beams. Then too, missile stability may require that the curve of error signal against angular error be linear for as large an angular region as possible. The whole question of the optimum crossover for guidance is unsettled. Perhaps the important point is that in a dual pulse system the tracking and guidance crossovers are relatively independent of each other.